
ताँबा एवं ताँबा मिश्रधातुओं की
टंगस्टन अक्रिय गैस हस्त्य आर्क
वेल्डिंग सम्बन्धी सिफारिशें
(पहला पुनरीक्षण)

**Recommendations for Manual
Tungsten Inert Gas Arc Welding
of Copper and Copper Alloys**
(First Revision)

ICS 160.10

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Welding Applications Sectional Committee had been approved by the Metallurgical Engineering Division Council .

This standard was first published in 1982. While reviewing this standard in the light of experience gained during these years, the Committee has decided to revise this standard to bring it in line with the present practices being followed by the Indian and Overseas industry.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RECOMMENDATIONS FOR MANUAL TUNGSTEN INERT GAS ARC WELDING OF COPPER AND COPPER ALLOYS

(*First Revision*)

1 SCOPE

1.1 This standard covers the recommendations on materials, equipment and general workmanship for manual tungsten inert gas arc welding of wrought copper and copper alloys. The recommendations are primarily intended for general engineering application for manual welding of copper and copper alloys up to 20 mm thick with argon, helium, nitrogen or a combination thereof as shielding gas.

1.1.1 This standard does not stipulate allowable stresses in welds. The provisions of this standard are also not applicable for repair of castings by welding.

2 REFERENCES

The standards given below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards:

<i>IS No.</i>	<i>Title</i>
812 : 1957	Glossary of terms relating to welding and cutting of metals
1747 : 1972	Specification for nitrogen (<i>first revision</i>)
5760 : 1998	Argon, compressed and liquid — Specification (<i>second revision</i>)
5898 : 1970	Specification of copper and copper alloy bare solid welding rods and electrodes

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 812 shall apply.

4 PARENT METAL AND FILLER WIRES

4.1 Base Metal

Following types of parent metals are covered in this standard:

- a) pure copper,
- b) silicon bronze,

- c) phosphor bronze,
- d) cupronickels,
- e) aluminium bronze,
- f) brasses,
- g) manganese bronzes,
- h) nickel silvers, and
- j) low-lead gun metal.

The alloys are indicated by the nominal composition in Table 1.

4.2 Filler Wires

4.2.1 The filler wires shall conform to the requirements of IS 5898.

4.2.2 For the selection of filler wires for different copper and copper alloys, reference shall be made to Table 1. The recommended filler wires are intended for general applications.

5 CURRENT CONDITION

5.1 Alternating current or direct current with electrode negative shall be used for welding copper and copper alloys.

5.2 Recommended current values for electrode and filler wire sizes chosen for different thicknesses of the copper and copper alloys are indicated in Tables 2 to 6.

6 WELDING TORCH

6.1 Air cooled torch with ceramic nozzle or water cooled torch with metal nozzle shall be used. For current values up to 200 A, air cooled torches may be used. For current values in excess of 200 A, water cooled torches shall be recommended.

6.2 Torches of up to about 300 A continuous rating are normally to be supplied with replaceable ceramic-shielding gas nozzles in a range of sizes. The nozzle size is selected to deliver the gas in a non-turbulent stream at a rate sufficient to protect fully the weld area from atmospheric oxidation. The use of a gas lense inside the nozzle gives a more stable gas stream over a greater distance from the nozzle; this permits longer electrode extensions when required, and a gas stream more resistant to cross draughts.

Table 1 Filler Wires for General Applications
(Clauses 4.1 and 4.2.2)

SI No.	Parent Metal			Filer Wire (See IS 5898)
	Material	Typical Composition		
		Constituent (3)	Percent (4)	
(1)	(2)			(5)
i)	Electrolytic tough pitch copper	Copper + Silver	99.90 <i>Min</i>	S-Cu 1
ii)	Phosphorus de-oxidized copper	Copper + Silver Phosphorus	99.80 <i>Min</i> 0.015-0.10	S- Cu 1
iii)	Silicon bronze	Silicon Zinc Tin + Manganese+ Iron Copper	1.0-1.3 1.25 1.0 <i>Max</i> Remaining	S- Cu Si 1
iv)	Phosphor bronze	Tin Phosphorus Copper	3.0-7.0 0.02-0.4 Remaining	S- Cu Sn 2
v)	Aluminium bronze	Aluminium Iron Copper	3.0-13 2.5 <i>Max</i> Remaining	S-Cu Al 1 S-Cu Al 2 S-Cu Al 3
vi)	Cupro nickel	a) Nicke Copper b) Nickel Copper c) Nickel Copper	10.0 Remaining 20.0 Remaining 30.0 Remaining	S-Cu Ni 1 S-Cu Ni 2 S-Cu Ni 3
vii)	Brasses	Copper + Zinc	Low zinc, up to 30 Zn High Zinc, 40 Zn	C9, C13 Not recommended
viii)	Nickel silvers	Cu+ Zn + Ni	20 Zn, 15 Ni 45 Zn, 10 Ni	C9, C13 Not recommended
ix)	Gun metal	—	Low lead	C9, C10, C13

Table 2 Current Values for Electrode
(Clause 5.2)

Sl No.	Tungsten Dia	Gas Cup Inside Dia	Typical Current Range				
			Direct Current	Alternating Current			
				70 Percent Penetration		(50/50) Balanced Wave A	
				Pure	Ceriated Thoriated Lanthanated	Pure	Ceriated Thoriated Lanthanated
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	0.040 in (1.016 mm)	(3/8 in) (9.5 mm)	15 - 80	20 - 60	15 - 80	10 - 30	20 - 60
ii)	0.060 in (1.52 mm)	(3/8 in) (9.5 mm)	70 - 150	50 - 100	70 - 150	30 - 80	60 - 120
iii)	0.093 in (2.36 mm)	(1/2 in) (0.5 mm)	150 - 250	100 - 160	140 - 235	0 - 130	100 - 180
iv)	0.125 in (3.17 mm)	(1/2 in) (0.5 mm)	250 - 400	150 - 200	225 - 325	100 - 190	160 - 250

NOTES

1 All values are based on the use of argon as a shielding gas. Other current values may be employed depending on the shielding gas, type of equipment and application.

2 DCEN = Direct Current Electrode Negative (Straight Polarity)

7 ELECTRODES

7.1 The electrodes shall be made out of pure tungsten, thoriated tungsten or zirconiated tungsten. Ceriated and lanthanated electrodes can also be used.

7.1.1 In the case of dc power with the electrode negative thoriated tungsten or pure tungsten electrodes shall be used.

7.1.2 In the case of ac power source zirconiated

tungsten or pure tungsten electrodes shall be used.

7.1.3 Ceriated tungsten electrodes may be used with either ac or DCEN.

7.1.4 Lanthanated electrodes generally have longer life and provide greater resistance to tungsten contamination of the weld. The lanthana is dispersed evenly throughout the entire length of the electrode and it maintains a sharpened point well, which is an advantage for welding steel and stainless steel on dc or the ac from Advanced square wave power sources. Thus the lanthanated electrodes work well on ac or dc electrode negative with a pointed end or they can be balled for use with ac sine wave power sources.

7.1.5 Electrodes for ac sine wave or conventional square wave should have a hemispheric or balled end formed. The diameter of the end should not exceed the diameter of the electrode by more than 1.5 times. If it becomes larger than this because of excessive current, there is the possibility of it dropping off to contaminate the weld. If the end is excessively large, and the current is decreased before the molten tip drops off, the arc tends to wander around on the large surface of the electrode tip. The arc becomes very hard to control as it wanders from side-to-side. If welding conditions are correct, a visual observation of the electrode should reveal a ball end of uniform shape and proper size. For improved arc focus set the balance control to maximum penetration, a ceriated, lanthanated or thoriated tungsten with a modified point may be used.

7.1.6 In DCEN, since most of the weld energy is provided by electrode negative, there is very little heating affect on the tungsten and a sharp pointed tungsten is generally preferred.

8 SHIELDING GAS

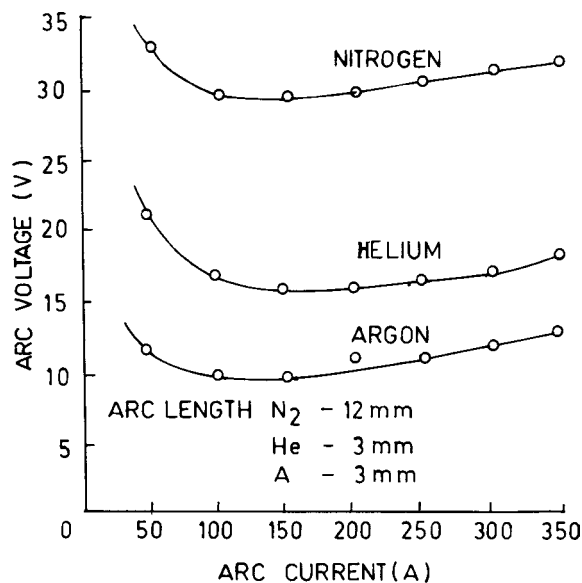
8.1 Quality

Argon gas used for the shielding purpose shall conform to IS 5760. Helium gas and nitrogen gas shall conform to IS 1747.

8.2 Flow Rate

The rate of flow of argon should be adequate to obtain a clean weld. This depends on several factors, such as, type of parent metal, current intensity, shape and size of nozzle, type of joint and where air draughts are present around the arc. Generally a higher rate of gas flow is required with higher welding currents, for corner joints, edge welds and work outdoors. Tables 3 to 6 give recommended flow rates for different weld thicknesses.

8.3 The arc voltage characteristics are characteristics of the shielding gas used. It is shown in Fig. 1.



All dimensions in millimetres.

FIG. 1 ARC VOLTAGE CHARACTERISTICS OF ARGON-HELIUM AND NITROGEN-SHIELDED TIG WELDING OF COPPER

8.4 If welding has to be done outdoors during inclement weather, especially during period of high wind, the welding area should be effectively protected by increased gas flow rate. Draughts tend to break gas shielding, resulting in porous oxide contaminated welds.

8.5 Generally speaking, when the welding current, nozzle diameter, or electrode stick out is increased, the flow rate should be increased. When welding in the ac mode the current reversals have a disturbing effect on the shielding gas and flow should be increased by 25 percent. And of course when welding in a drafty situation, flow rate should be doubled. When welding corner/edge joints, excessive flow rates can cause air entrapment. In this situation, the effectiveness of the shielding gas can be improved by reducing the gas flow by about 25 percent.

9 PREPARATION OF PARENT METAL

Before welding, joints should be cleaned thoroughly to remove foreign matter, such as, oil, grease, dirt, paint, etc. This is usually achieved by degreasing or pickling or both followed by brushing.

9.1 Degreasing

Joints may be cleaned with solvent soaked rags to remove surface oil, grease, dirt, etc. Suitable solvents include carbon tetrachloride, acetone and trichloroethylene. It is essential to ensure that the components are completely dry of solvents before

welding. Some jobs may also be immersed in or sprayed with these degreasing agents. Vapour degreasing; by steam, with or without a cleaner or high-pressure water jetting may also be used.

9.2 Pickling

Heavy oxide films may be cleaned by pickling. This should be done before welding.

9.3 Brushing

Following degreasing or pickling or both, the fusion faces of copper and its alloys should be scratch-

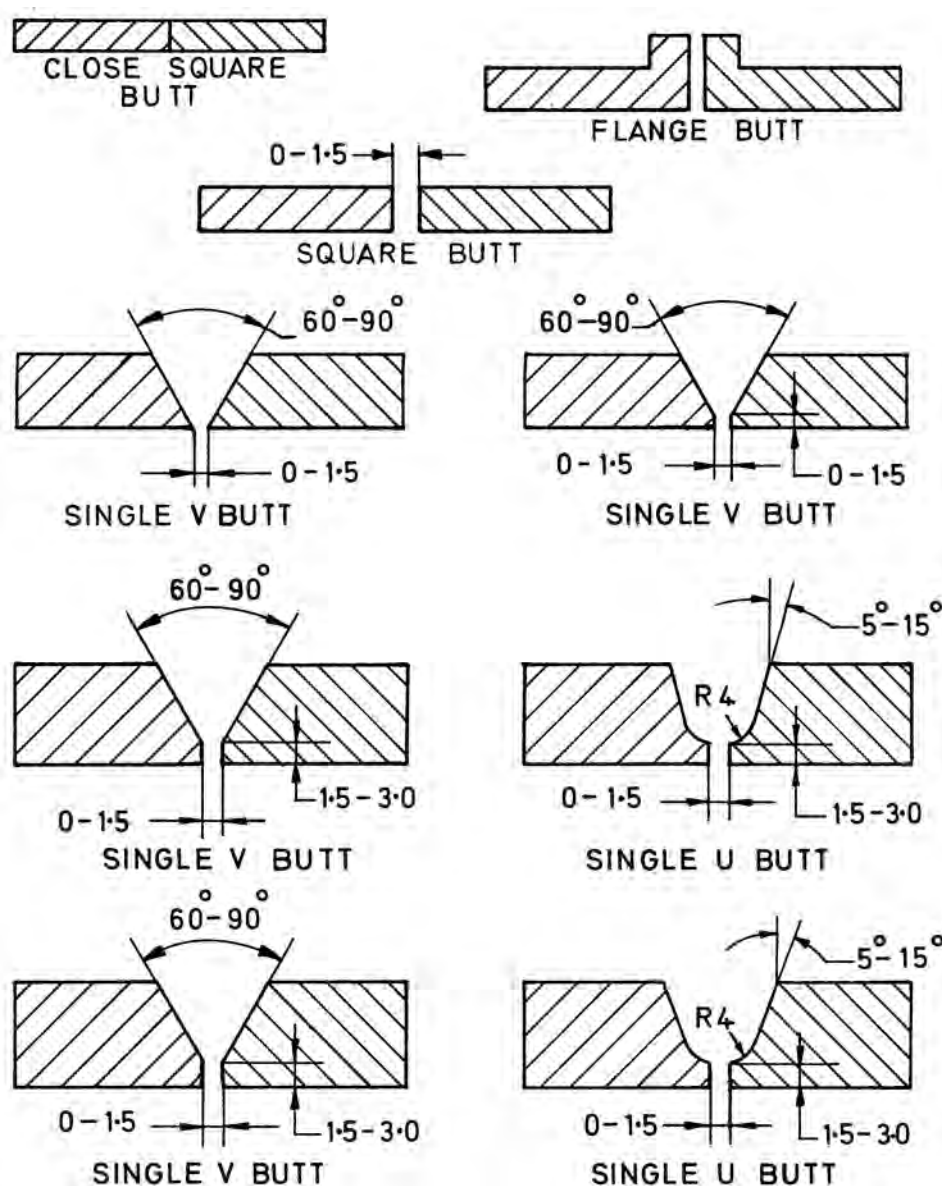
brushed with wire brushes. These brushes should not have been used for scratch brushing materials other than copper.

10 DESIGN OF EDGE FORMS

10.1 Recommended edge forms for butt joints up to 20 mm metal thickness are shown in Fig. 2.

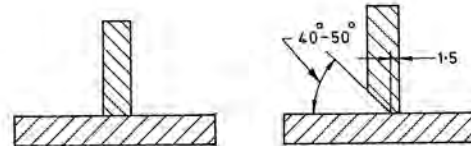
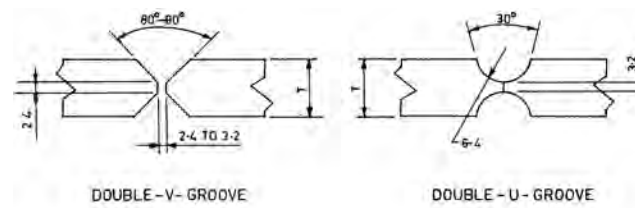
10.2 Recommended types of tee-joints are shown in Fig. 3.

10.3 Recommended types of corner joints are shown in Fig. 4.



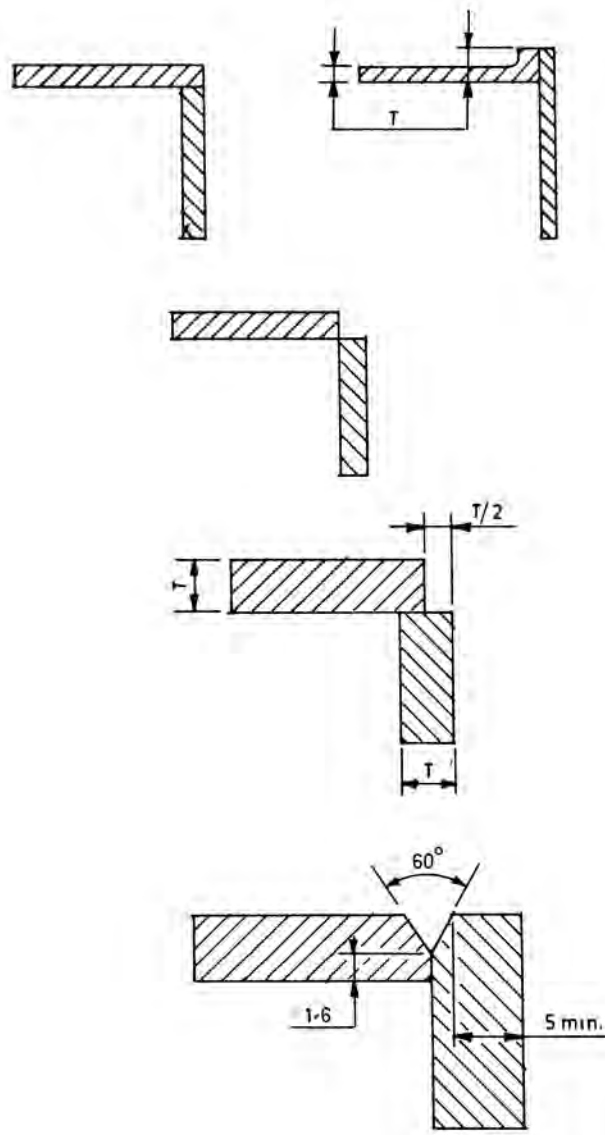
All dimensions in millimetres.

FIG. 2 RECOMMENDED EDGE PREPARATIONS FOR DOWNHAND BUTT WELDS



All dimensions in millimetres.

FIG. 3 TEE JOINTS



All dimensions in millimetres.

FIG. 4 CORNER JOINTS

11 ASSEMBLY FOR WELDING

11.1 To maintain alignment during welding, the parts should be located by mechanical means or by tack welding.

11.2 If a jig is not used, the edges should be kept in alignment in assembly prior to welding by tack welds spaced at regular intervals along the joints. The tack welds should be either melted out during welding or made a part of and the same quality as the main weld. Defective tack welds should be removed before welding commences. After the tack welding, the weld should be scratch-brushed before regular welding is commenced.

11.3 Backing bars when employed may be of mild steel or copper and should be maintained in a clean condition free from grease, dirt, moisture and rust. Typical backing bars are illustrated in Fig. 5. Argon backing could also be used with advantage especially with thinner gauges. For keeping the backing bars clean, steel and copper backing bars may be given a thin coating of chromium.

12 PREHEATING

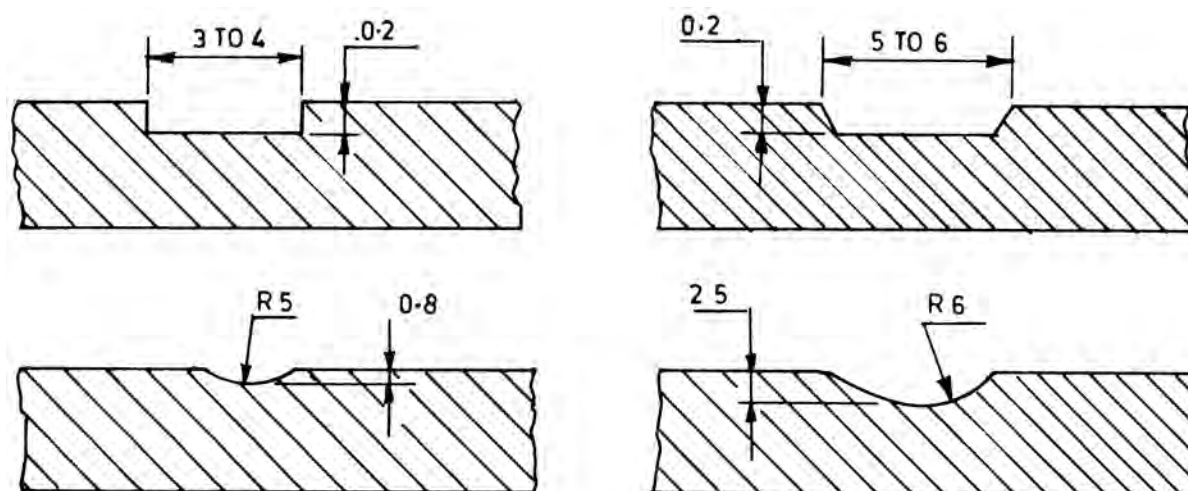
12.1 Preheating shall be necessary for most of the copper and copper alloys. When required, oxy-acetylene or oxy-propane torches, or resistance-heated blankets may be used. For recommendations on preheating, reference may be made to Tables 3 to 6.

12.2 Since copper and copper alloys are extremely good conductors of heat, heat drain causes a problem during preheat treatment. Heat drain may be minimized by the use of asbestos lagging/blanket.

13 WELDING OPERATION

13.1 While welding in flat position, the torch is held nearly vertical. It is normal to apply leftward welding technique. When the weld pool is established, it is moved slowly along the joint, adding filler alloy in discrete amounts as welding proceeds. The tip of the filler rod must remain within the protective gas shield at all times.

13.2 Particular care must be taken when depositing



All dimensions in millimetres.

FIG. 5 TYPES OF TEMPORARY BACKING BARS

Table 3 Typical Operating Data for GTAW Butt Welds in Copper
(dc Electrode, Negative Argon Shielding)
(Clauses 5.2, 8.2 and 12.1)

Sl No.	Thickness mm	Preheat Temp °C	Electrode Diameter mm	Filler Rod Dia mm	Gas Nozzle Dia mm	Argon Gas Flow l/min	Welding Current A	No. of Passes	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	1.5	—	1.6-2.4	1.6	9.5	4- 6	80-130	1	Hot peening required
ii)	3	—	2.4-3.2	1.6	9.5 - 12	4- 6	120-240	1-2	Hot peening required
iii)	6	200-300	3.2-4.8	3.2	12 - 18	6- 8	220-350	2-3	Hot peening required
iv)	9	300-350	3.2-4.8	3.2	12 - 18	8-10	300-375	3-4	Hot peening required
v)	12	350-400	4.8	3.2-4.8	12 - 18	8-10	330-420	4-6	Hot peening required
vi)	16-20	350-450	4.8	3.2-4.8	12 - 18	8-10	400-475	6-8	Hot peening required

Table 4 Typical Operating Data for GTAW Butt Welds in Silicon Bronze
(ac, dc Electrode Negative)
(Clauses 5.2, 8.2 and 12.1)

Sl No.	Thickness mm	Preheat Temp °C	Electrode Diameter mm	Filler Rod Dia mm	Gas Nozzle Dia mm	Argon Gas Flow l/min	Welding Current A	No. of Passes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	1.5	—	3.2	1.6	9.5 -12	5- 8	100-130	1
ii)	3	—	3.2	1.6	9.5 -12	5- 8	120-160	1-2
iii)	6	—	3.2	3.2	12-18	8-10	200-300	2-3
iv)	9	—	3.2	3.2	12-18	8-10	250-300	3-4
v)	12	—	3.2	3.2-4.8	12-18	8-10	270-330	4-6
vi)	16-20	—	3.2-4.8	3.2-4.8	12-18	8-10	300-375	6-8

Table 5 Typical Operating Data for GTAW Butt Welding of Aluminium Bronze
(ac, Argon Shielding)
(Clauses 5.2, 8.2 and 12.1)

Sl No.	Thickness mm	Preheat Temp °C	Electrode Diameter mm	Filler Rod Dia mm	Gas Nozzle Dia mm	Argon Gas Flow l/min	Welding Current A	No. of Passes	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	1.5	—	3.2	1.6	9.5 - 12	5- 8	100-130	1	Hot peening required
ii)	3	—	3.2	3.2	9.5 - 12	5- 8	180-220	1-2	Hot peening required
iii)	6	150 Max	3.2	3.2	12 - 18	8-10	280-320	2-3	Hot peening required
iv)	9	150 Max	3.2	3.2-4.8	12 - 18	8-10	320-400	3-4	Hot peening required
v)	12	150 Max	3.2	3.2-4.8	12 - 18	8-10	360-420	4-6	Hot peening required
vi)	16-20	150 Max	3.2	3.2-4.8	12 - 18	8-10	400-475	6-8	Hot peening required

Table 6 Typical Operating Data for GTAW Butt Welding in Cupro Nickel
(dc Electrode Negative, Argon Shielding)
(Clauses 5.2, 8.2 and 12.1)

Sl No.	Thickness mm	Preheat Temp °C	Electrode Diameter mm	Filler Rod Dia mm	Gas Nozzle Dia mm	Argon Gas Flow l/min	Welding Current A	No. of Passes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	1.5	—	3.2	1.6	9.5 -12	8-10	100-140	1
ii)	3	—	3.2	1.6	9.5 -12	8-10	140-200	1-2
iii)	6	150 Max	3.2	3.2-4.8	12-18	9-12	180-260	2-3
iv)	9	150 Max	3.2	3.2-4.8	12-18	9-12	260-320	3-4
v)	12	150 Max	3.2	3.2-4.8	12-18	9-12	320-400	4-6
vi)	16-20	150 Max	3.2-4.8	3.2-4.8	12-18	9-12	360-450	6-8

the root run. The root weld deposit must contain at least 50 percent by volume of filler alloy to avoid the risks of weld sagging, burn-through, porosity and grain-boundary oxide films.

13.3 When controlled root penetration is required on unsupported butt joints, a 'keyhole' may be formed through the joint by melting the root faces. Filler rod is introduced into the 'keyhole' sufficient to fill it and bridge the root gap. The torch is then moved forward to reform the 'keyhole' and the process repeated until the root run is completed.

13.4 GTAW welding is applicable to all welding positions except the vertical, but the ease with which the positional welding is accomplished depends to a large extent upon operator skill and material thickness, which determines the size of the weld pool.

14 POSTWELD HEAT TREATMENT

14.1 Postweld heat treatment is generally not necessary in case of copper and copper alloys.

14.2 In case of aluminum bronze and phosphor bronze and for certain applications where severe stress corrosion cracking may be feared, stress relief heat treatment or annealing treatment may be carried out. For recommended heat treatment temperature range, reference may be made to Table 7.

14.3 In case of postweld heat treatment sufficient care shall be exercised to ensure freedom from impurities in the furnace atmosphere which result in higher sulphur ingredients. Presence of such impurities can cause cracking due to formation of low temperature melting copper sulphides and nickel sulphides in the case of cupro nickel.

Table 7 Heat Treatment Temperature
(Clause 14.2)

Sl No.	Material °C	S.R. Heat Temperature ¹⁾ °C	Annealing Temp ²⁾
(1)	(2)	(3)	(4)
i)	Pure copper	—	370-650
ii)	Aluminum bronze	593-650	675-815
iii)	Silicon bronze	450	482-675
iv)	Phosphor bronze	—	482-650
v)	Cupro nickel	530	650-816
vi)	Red brass	288	427-732
vii)	Admiralty brass	288	427-593

¹⁾ Heat slowly to these temperatures and hold for 1h , min.

²⁾ Heat slowly to these temperatures and hold for 15 to 30 min.

Lead, phosphorus and sulphur are highly detrimental as they cause inter-granular hot cracking in highly restrained joints. It is essential that the surfaces be kept free of such contaminating elements before heating to high temperature, such as, in annealing or welding.

Common sources of such contaminating elements are marking crayons, paints, temperature indication markers, cutting fluids, oil and grease.

15 TESTING AND INSPECTION

15.1 The method of inspection should be in accordance with the requirements of appropriate Indian Standards or in the absence of such standards, by agreement between the purchaser and the fabricator.

15.2 Welds not complying with such standards shall be cut out and re-welded and re-inspected.

15.3 The fabricator shall be responsible for the supply of material for testing, preparation of test piece, labour and appliances required for such testing as may be carried out in his premises by the purchaser. If such facilities are not available at his premises for carrying out such prescribed tests, the fabricator shall have the tests carried out elsewhere.

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

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Amendments Issued Since Publication

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